Project NY 411 002-1
Technical Memorandum M-072

# RECOMMENDED TECHNIQUES FOR THE SUPPRESSION OF RADIO INTERFERENCE FROM ENGINE GENERATOR SETS

28 August 1952

u. s.
naval
civil
engineering
research
and
evaluation
laboratory

port hueneme,
california

U.S. Naval Civil Engineering Research and Evaluation Laboratory,
Port Hueneme, California

Project NY 411 002-1
Technical Memorandum M-072

# RECOMMENDED TECHNIQUES FOR THE SUPPRESSION OF RADIO INTERFERENCE FROM ENGINE GENERATOR SETS

28 August 1952

A. M. INTRATOR

SUMMARY

Reports from Navy procurement and inspection authorities have indicated that equipment from some manufacturers do not conform to Navy radio-interference specifications because the manufacturers are not aware of the measures necessary to suppress their equipment adequately. Much of this equipment generated interference because of improperly suppressed ignition systems or rotating electrical machinery. Engine-driven electric generators are typical of such equipment; and the methods used to suppress them can, in general, be applied to other engine ignition systems and rotating machinery. This report describes and recommends methods to reduce interference from engine generator sets.

CONTENTS

ILLUSTRATIONS

## INTRODUCTION

The greater sensitivity and complexity of today's electronic equipment have made them more susceptible to radio interference than was earlier equipment, and the increasing use by the armed forces of electrical and electronic devices has introduced more and more sources of potential interference. This combination of factors has resulted in radio interference becoming a serious military operational hazard.

Since the sensitivity of the equipment cannot be compromised, other methods of solving the radio-interference problem must be sought. These may range from developing more discriminatory information-sampling techniques in the affected equipment to reducing the radio-influence factor of the potential source. Reduction of the interference at the source is essentially a matter of considering, in the design of the equipment, adequate shielding, proper filtering, bonding, and so on. However, discussions with personnel of the procurement and inspection agencies have indicated that many manufacturers do not take these matters into account in the design of their equipment, primarily because they do not know what must be done.

Much of the interference at Naval Shore Stations results from the operation of automotive equipment or electrical rotating machinery of one type or another. An engine-driven electric generator is typical of the equipment used, and the techniques used in minimizing interference from such a unit could be applied to the suppression of radio interference from related machinery, such as small electric drive motors or stationary industrial engines.

The U.S. Naval Civil Engineering Research and Evaluation Laboratory, under project NY 411 002-1, "Suppression of Radio Interference," has studied methods of reducing the radio-influence factor of engine-driven generators. It is the purpose of this report to describe many of the methods which have been successfully used in order to provide information which may be useful in the suppression of radio interference from engine generators.

## SUPPRESSION METHODS

There are two major sources of noise in engine generator sets, the engine ignition system and the electric generator.

## The Engine Ignition System

Most of the engines are gasoline driven and have an ignition system similar to that shown in Figure 1. The ignition system is essentially a spark generator utilized to provide a timed intermittent spark for the explosion of the fuel. Many early radio transmitters operated on the principle of having a spark-discharge shock excite a tuned circuit, causing it to radiate. A tuned circuit, in effect, exists in the engine ignition system, the tuned circuit consisting of the cables and other ignition components. Here the excitation impulse is provided not only by a major arc source, as in the plugs, but also by the discharges across the breaker points in the voltage regulator and in the other ignition components. The numerous studies made of the radio interference emitted by automotive ignition systems indicate that the frequency spectrum of such radiation is very broad.[1,2,3,4,5] This broadness of the frequency spectrum is one of the reasons why ignition interference is so serious a problem.

A number of techniques have been successfully used to suppress the interference from ignition systems. It was realized that elimination of unwanted contactor arcing would reduce the interference and that alteration of the circuit parameters might also effect such reduction. The undesirable discharges usually occurred in distributors, voltage regulators, and magnetos. To reduce the intensity of the discharge, capacitors are usually placed across the arcing terminals. The capacitor shares some of the charge being built up across the terminals and, since the initiating voltages are transient in nature, serves to reduce the voltage developed across the gap. Its effectiveness depends upon the period and wave shape of the applied voltage and upon the size of the condenser, the effectiveness of the condenser increasing with increased capacity. The use of a condenser may sometimes eliminate the arc entirely, but more often it merely decreases the magnitude and period of the arc. The maximum size of the capacitor is limited by physical and economic consideration, with 0.1-μf condensers being most frequently used for ignition-system suppression.

Because such methods obviously cannot be applied to the spark-plug discharge, other techniques and circuit modifications must be considered. Introduction of a series resistance into the spark-plug circuit was found to offer some success in suppressing the radiated noise.[6,7] Spark plugs with built-in 10,000-ohm resistors are now commercially available and are often used in reducing radio interference from an ignition system.

Although these measures reduce somewhat the intensity and spectrum of the interference generated by ignition systems, they are not completely successful in minimizing the interference to

the levels tolerated by military specifications. To meet military specifications, an adequate shielding system is required. To be shielded adequately, the ignition system must be enclosed within a continuous metallic housing, usually steel, bronze, brass, or copper. The shield confines any generated interference within the system and prevents it from being radiated. The shielding system is essentially that shown in Figure 2. It consists of integrally shielded (aircraft type) spark plugs with built-in suppression resistors; flexible metallic hose in which all cable are inserted; special connectors to maintain the shielding continuity of the components; and metallic housings for the distributor and coil or magneto, voltage regulator, etc. Figures 3 through 6 show some of these suppression units, and Figures 7 and 8 show a suppression system installed on a 6-cylinder Chrysler automobile engine.

Engines that use a distributor and coil have a battery, generator, and voltage regulator as part of the ignition system. Those using magnetos do not require this additional equipment. Though a reduction in potential sources of interference is obtained with use of the magneto, certain precautions must be observed when a magneto system is used. It was learned that an exposed magneto coupling can be a serious source of interference even though it is not an integral part of the ignition electrical system.[6] Figure 9 shows an exposed magneto shaft on an engine generator which was found to be particularly troublesome in this respect. Only by shielding the shaft was the interference satisfactorily minimized. In this particular instance, a spun-steel housing was used,as shown in Figure 10.

Diesel and semidiesel engines are sometimes used in engine generator sets. Ignition-suppression requirements for these engines are obviously less than are those demanded by the more complex ignition systems used in gasoline-driven equipment.

In all instances, care must be taken to see that good, firm, continuous electrical contact is made at all joints and connections in the suppression system in order to maintain the shielding integrity. Leakage of energy can occur at cracks and loose connections in the shield, and this leakage may become very serious, especially at high frequencies.

Table 1 lists the minimum measures to be considered in suppressing ignition systems, and the Appendix presents a list of manufacturers who have previously supplied acceptable ignition-suppression components to the Navy.

## The Generator

The generation of radio interference in rotating electrical machinery is usually attributed to arcing between the brushes and slip rings or commutator. These transient currents shock-excite portions of the machine and result in a radiation of high-frequency energy much in the same manner as that in which radiation is caused in an ignition system. However, the radio-interference generated in this manner is considered random in character, since the voltages which cause noise do not occur in a definite pattern or at a definite repetition rate and cannot be synchronized on the screen of an oscilloscope.[6] Direct-current machines are a more serious source of interference than are alternating-current machines. Certain basic design modifications, such as the use of laminated brushes or more secure brush-holding mechanisms, have been used, with some success, to obtain a reduction in the generated interference.[7] The noise from existing machines is generally quite successfully minimized by placing capacitors across the brushes. Ordinarily 0.1-µf capacitors of the appropriate voltage rating have been found adequate.

Table 2 lists the minimum measures that must be considered when suppressing the generator. If these precautions are taken, the generator housing is usually sufficient to prevent excessive radiation, and no additional shielding of the machine is needed. However, noise conducted by the generator output lines is not always reduced sufficiently by these measures. To prevent such interference from reaching the distribution panel, each of the generator output lines must be filtered and the filters so mounted that the external coupling of any noise voltages from the input to the output filter terminals is avoided. Figure 11 illustrates how this decoupling may be accomplished. The partition in the enclosure shield the filter terminals from each other.

It is also advisable to shield the output lines from their point of exit at the generator to their entrance into the filter enclosure, although the filtered lines going to the output terminals on the distribution panel need not necessarily be shielded if care is taken to keep them short and as far away from the generator housing as practicable. Figures 12 and 13 show correct and incorrect placement of the output leads of a filter.

It is important that secure electrical contact be made between all "ground-reference" parts of the equipment (i.e., the frame, engine block, generator housing, shield enclosures,metal panel board, etc.). Tinned copper bonding straps, fastened with bolts or screws using lock-tooth washers, should be employed.

Switch and meter leads can be serious radiators of noise, and it is recommended that they be shielded. The shielding hose should be well grounded to reduce any possibility of parasitic radiation.

These interference-reduction methods have been successful in the past in suppressing engine generators in accordance with Navy interference specifications. It must be realized, however, that in general each machine will present individual suppression problems: these measures are suggested as "good practice techniques" and are only the minimum precautions to be observed.

RECOMMENDATIONS

It is recommended that the manufacturer, the maintenance man, and the inspector be supplied with information on suppression techniques as guides in providing equipment with a minimum of interference.

REFERENCES

1. Eaglesfield, C.C., "Car Ignition Radiation," Wireless Engineer, vol. 28, January 1951, pp. 17-22.

2. Eaglesfield, C.C., "Motor Car Ignition Interference," Wireless Engineer, vol. 23, October 1946, pp. 265-272.

3. Nethercot, W., "Car Ignition Interference," Wireless Engineer, vol. 26, August 1949, pp. 251-255.

4. Cressey, B.G., and G.E. Ashwell, "Radiation from Car Ignition Systems," Wireless Engineer, vol. 26, January 1949, pp. 31-36.

5. Teliviso Corporation, Instrument Development Division, Report No. 102, Report No. 1 on Conduction of Studies on Radio Interference Reduction, 16 August 1951.

6. Motter, D.P., "Commutation of D.C. Machines and Its Effects on Radio Interference Voltage Generation," Transactions of the American Institute of Electrical Engineering, vol. 68, Pt. I, 1949, pp. 491-496.

7. General Engineering and Consulting Laboratory, General Electric Company, Report R50GL125, Investigation of Radio Noise Generation in Aircraft Electrical Machinery, July 1950.

APPENDIX

List of manufacturers whose components have been found suitable for Naval use in the suppression of radio interference for engine-generator sets.[5]

Spark Plugs

The B.G. Corporation
136 West 52nd Street
New York, New York

The Electric Auto-Lite Company
Toledo, Ohio

Champion Spark Plug Company
Toledo, Ohio

A.C. Spark Plug Division
General Motors Corporation
Flint, Michigan

Shielding Conduit (Metallic Hose)

The Breeze Corporation
41 South 6th Street
Newark, New Jersey

Titeflex, Incorporated
500 Frelinghuysen Avenue
Newark 5, New Jersey

Connectors

Airtron, Incorporated
Pleasant Plains, S.I., New York

The Breeze Corporation
41 South 6th Street
Newark, New Jersey

The B.G. Corporation
136 West 52nd Street
New York, New York

Bendix Scintilla Division
Bendix Aviation Corporation
Sidney, New York

Cannon Electric Development Company
3209 Humboldt Street
Los Angeles 31, California

Electrical and Mechanical Design Corporation
Toledo, Ohio

Hallett Manufacturing Company
1601 West Florence Avenue
Inglewood, California

Titeflex, Incorporated
500 Frelinghuysen Avenue
Newark 5, New Jersey

Shielding Enclosures

American Bosch Magneto Company
Springfield, Massachusetts

Electrical and Mechanical Design Corporation
Toledo, Ohio

The Breeze Corporation
41 South 6th Street
Newark, New Jersey

Hallett Corporation
1601 West Florence Avenue
Inglewood, California

Power Line Filters

Hopkins Engineering Company
2082 Lincoln Avenue
Altadena, California

Tobe Deutschmann Corporation
Norwood, Massachusetts

Sprague Electric Company
North Adams, Massachusetts

Aerovox Corporation
New Bedford, Massachusetts

Table 1. Recommended Suppression Techniques for Engine Ignition Systems.

| Component | Suppression Technique |
|---|---|
| Spark plugs | Integrally shielded resistor plugs (aircraft type) |
| Distributor | Completely enclosed in aluminum, brass, bronze, copper or steel housing. |
| Coil | Completely enclosed in aluminum, brass, bronze, copper or steel housing. Battery terminal of ignition coil by-passed to shield by 0.1-µf, 100-volts, dc capacitor. |
| Magneto | Completely enclosed in aluminum, brass, bronze, copper or steel housing. Exposed drive-shaft shielded. |
| Voltage regulator | Completely enclosed in aluminum, brass, bronze, copper or steel housing. Armature and battery terminals of regulator must be by-passed to shield by 0.1-µf, 1000-volt, dc capacitor. |
| Shielding enclosures | Particular attention must be given to the joints. To maintain optimum shielding efficiency, good electrical contact is required between sections completely around the periphery of the joint. A "socket or sphere-in-cone" joint, such as used in standard cable connectors, a "metallic gasket-in-groove" joint, a "paint-can-cover" joint, a "lip or flat-seat" joint have all been found acceptable when properly made. With "flat-seat" joints, it was found that the mating surfaces should have a minimum width of 7/16 inch. Fittings to accept harness should be welded, brazed, silver soldered, or threaded on. The enclosures should be individually bonded to the engine block by means of tinned copper bonding straps and lock-tooth washers. |
| Cable harness | All exposed wiring should be enclosed in three-layer flexible metallic hose (Titeflex type 154 or equivalent). End connectors should be soldered to the hose. |
| Battery charging generator | Output terminals to be completely shielded. Shield should be provided with fitting to accept and connector of shielded cable. |
| Mounting Brackets | Mounting brackets and the components thereon attached should be bonded to each other and to the engine frame by means of lock-tooth washers. |

Table 2. Recommended Suppression Techniques for Rotating Electrical Machinery

| Component | Suppression Techniques |
|---|---|
| Exciter brushes | Bypass exciter brushes to the brush-holding rig by 0.1-μf condensers of appropriate voltage rating. |
| Brush rig | Bond brush ring to the generator frame with tinned copper-braid grounding strap and tooth-type lock washers. |
| Commutator or slip-ring brushes | By-pass brushes to inside of generator housing by 0.1-μf capacitors of appropriate voltage rating. |
| Generator output terminals | By-pass terminals to generator housing by 0.1-μf capacitors of appropriate voltage rating. |
| Generator frame sections and bell housing | Secure generator frame sections and bell housing to each other with tooth-type lock washers. Ground generator frame to skid frame with tinned copper-braid strap and lock-tooth type of washers. |
| Generator output to distribution panel | Filter generator output. Shield leads from output terminals to power-line filter. Filter output may remain unshielded. |

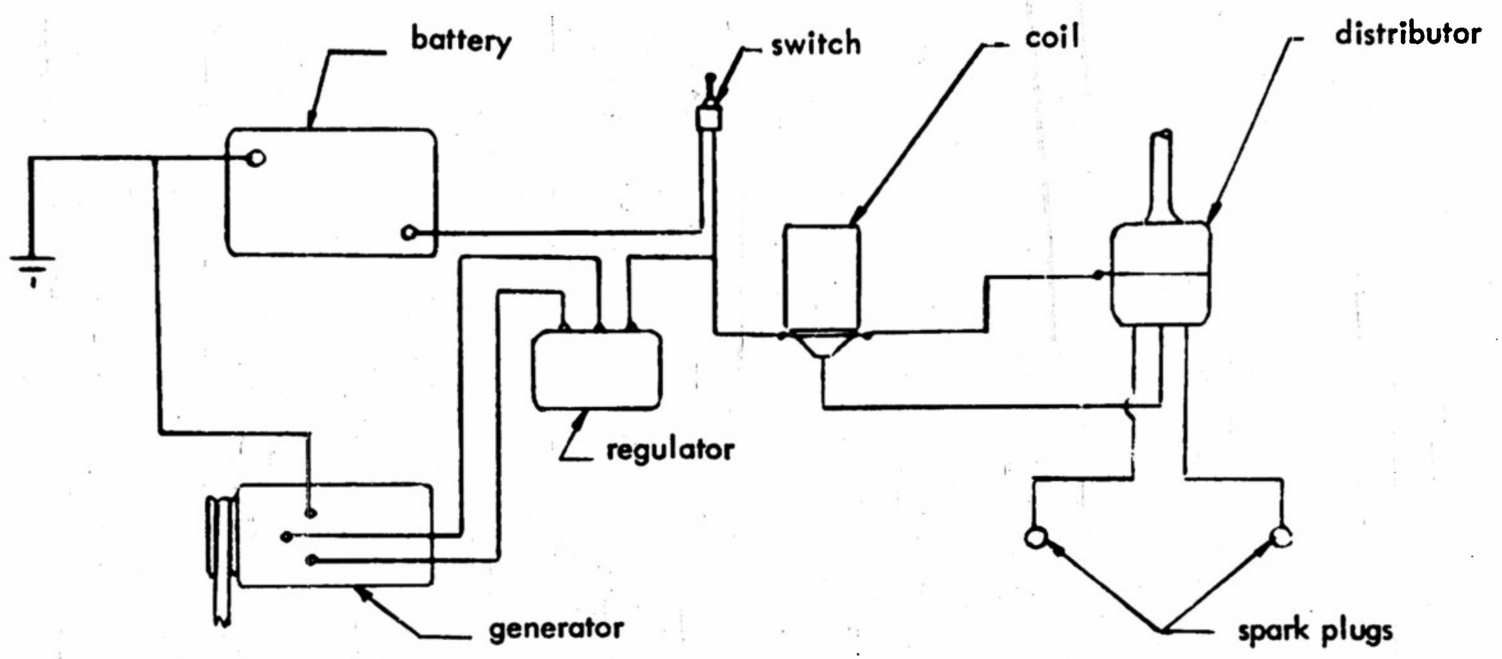


Figure 1. Schematic layout of an engine ignition system.

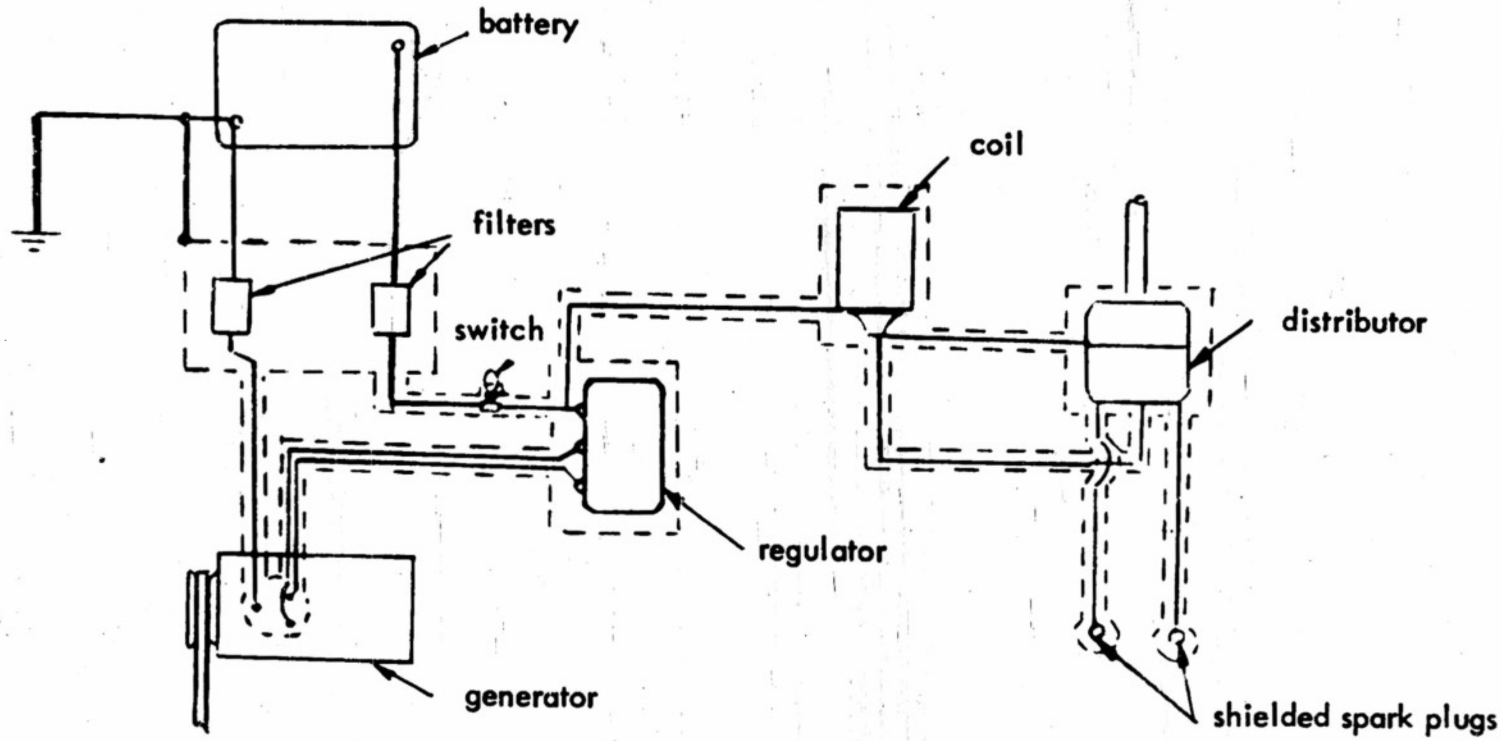


Figure 2. Schematic layout of a shielded engine ignition system. Dotted lines represent shielding.

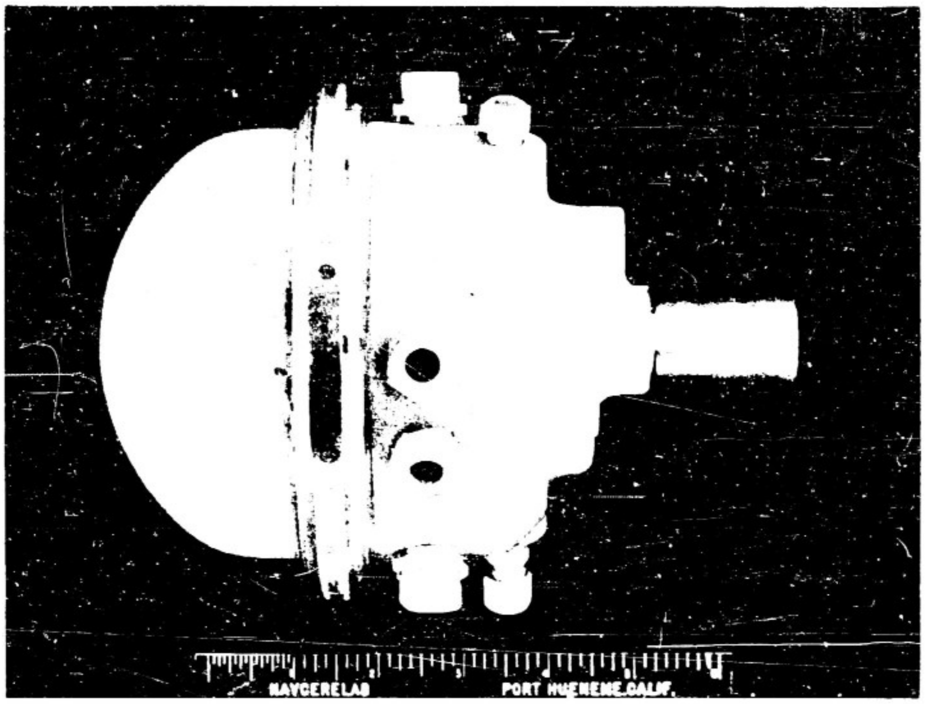


Figure 3. A typical ignition shielding enclosure. (Assembled distributor shield.)

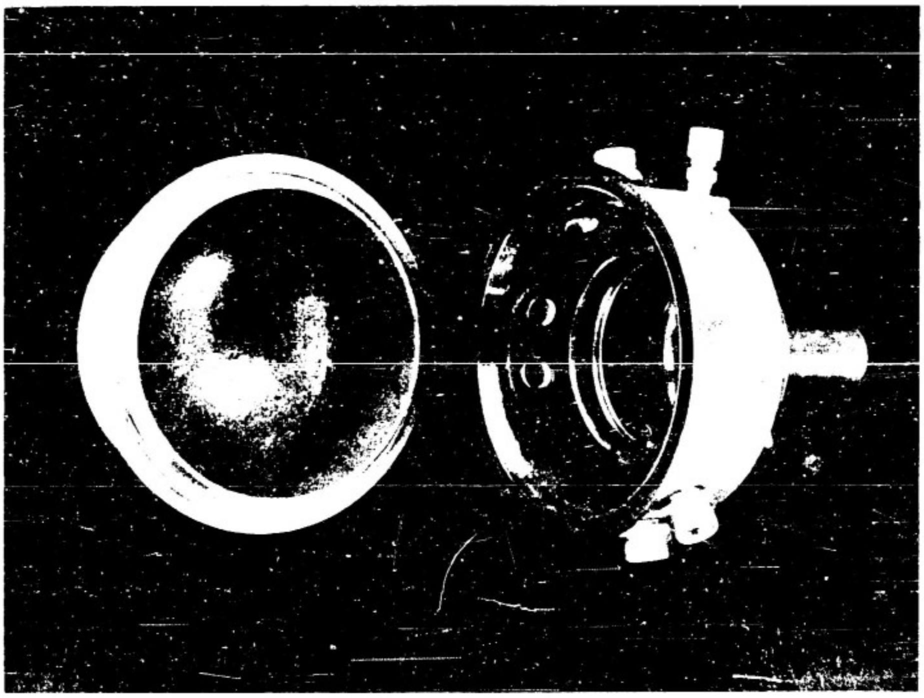

Figure 4. Open distributor shield.

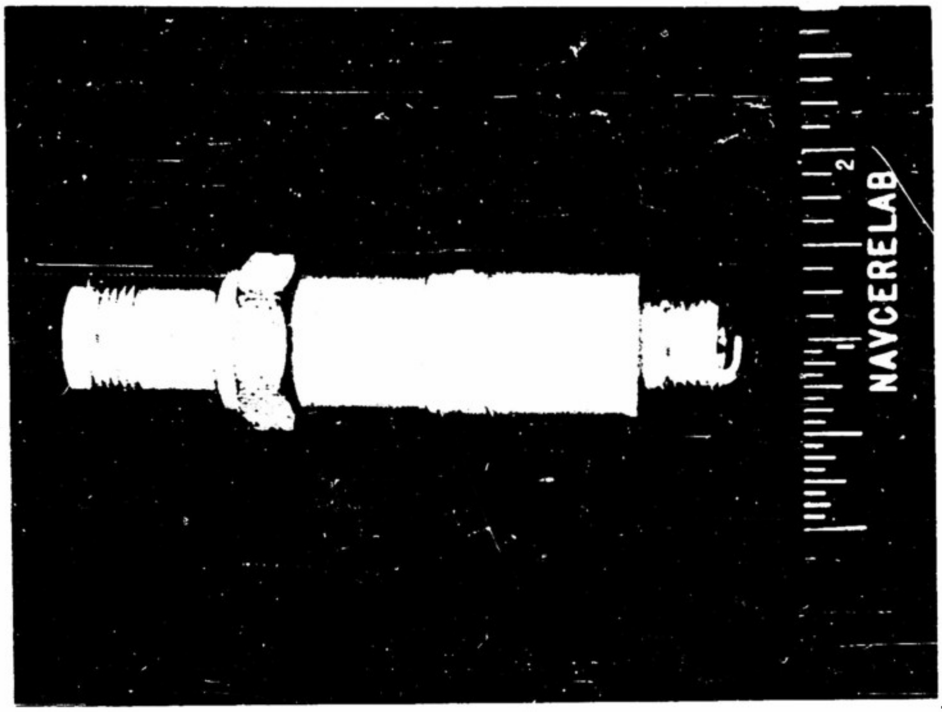


Figure 5. Integrally shielded spark plug.

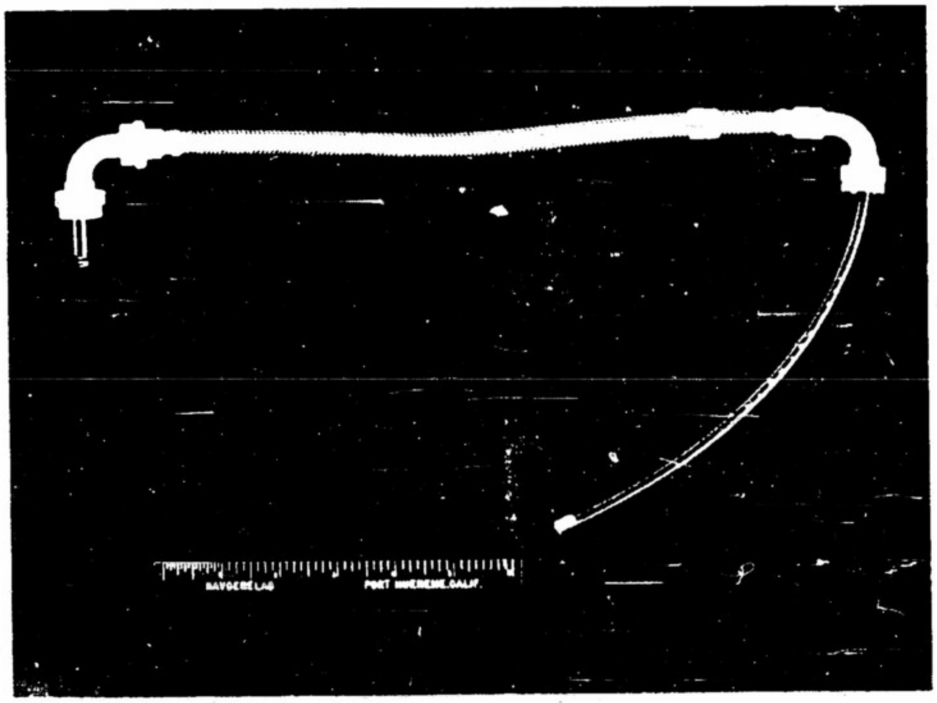

Figure 6. Shielded spark-plug cable.

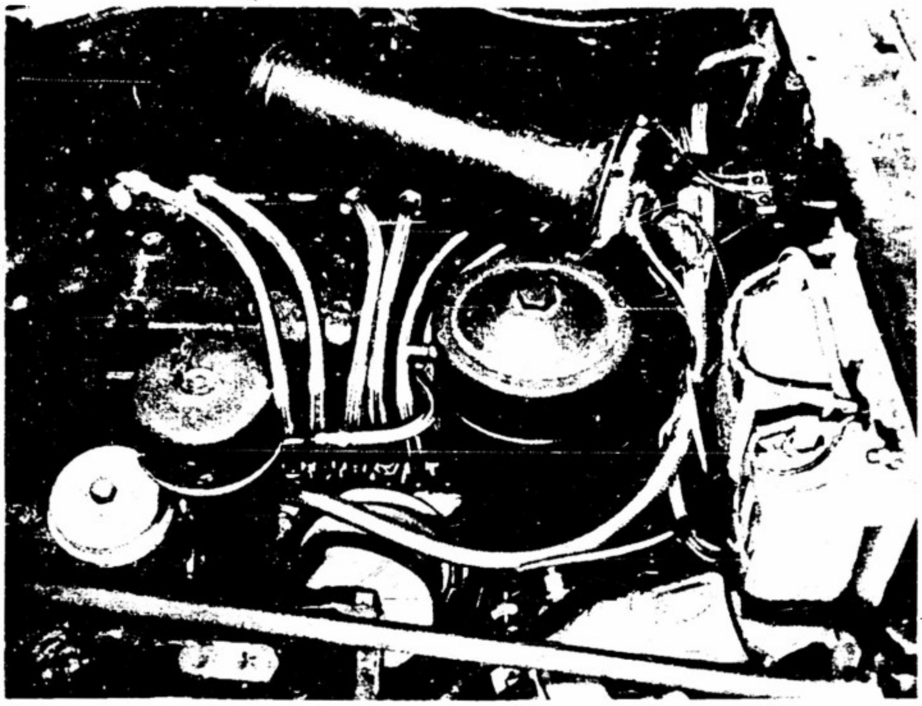

Figure 7. Side view of a shielded 6-cylinder Chrysler engine.

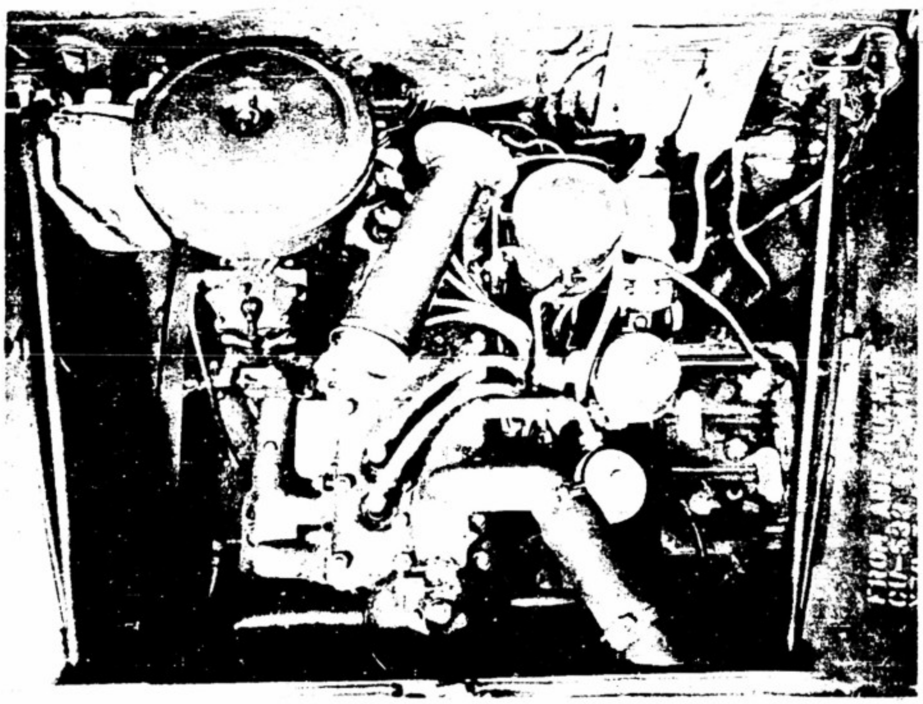

Figure 8. Front view of a shielded 6-cylinder Chrysler engine.

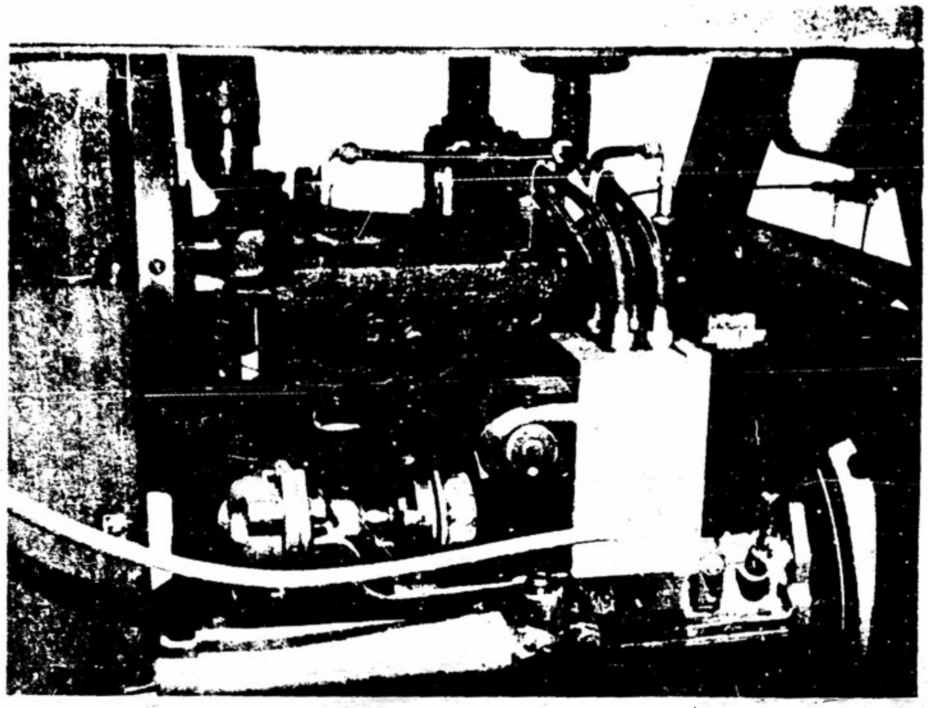

Figure 9. Exposed magneto shaft.

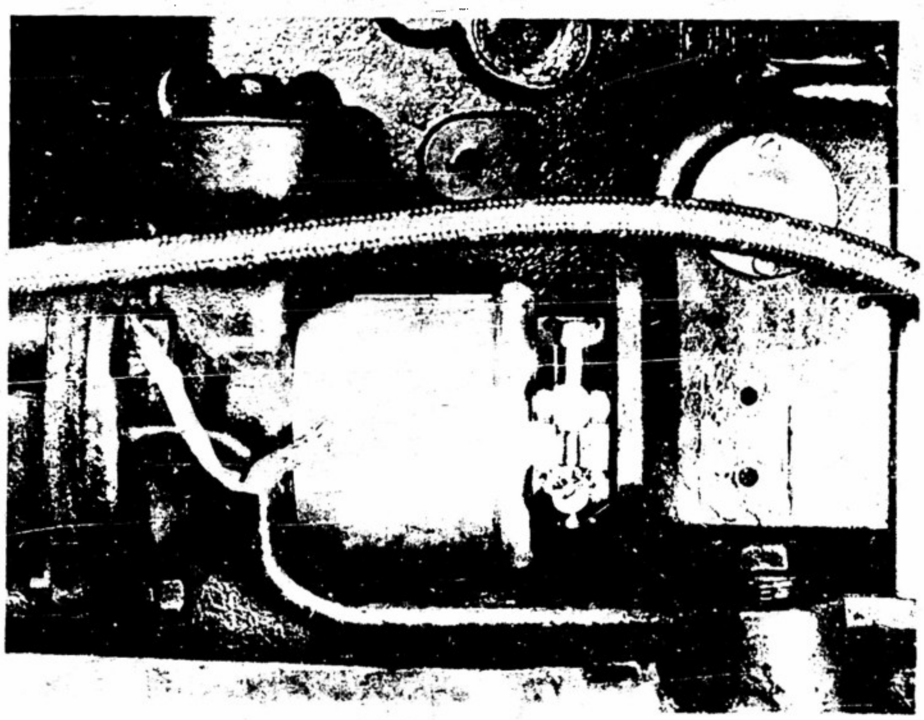

Figure 10. Magneto shaft shielded with spun-steel enclosure.

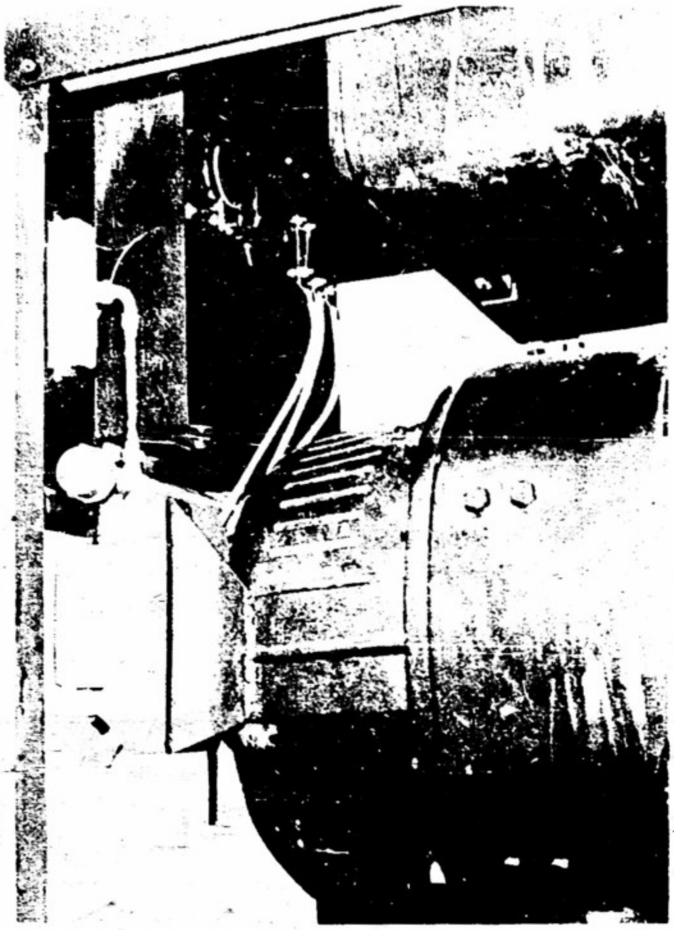

Figure 12. Incorrect placement of filter output leads.

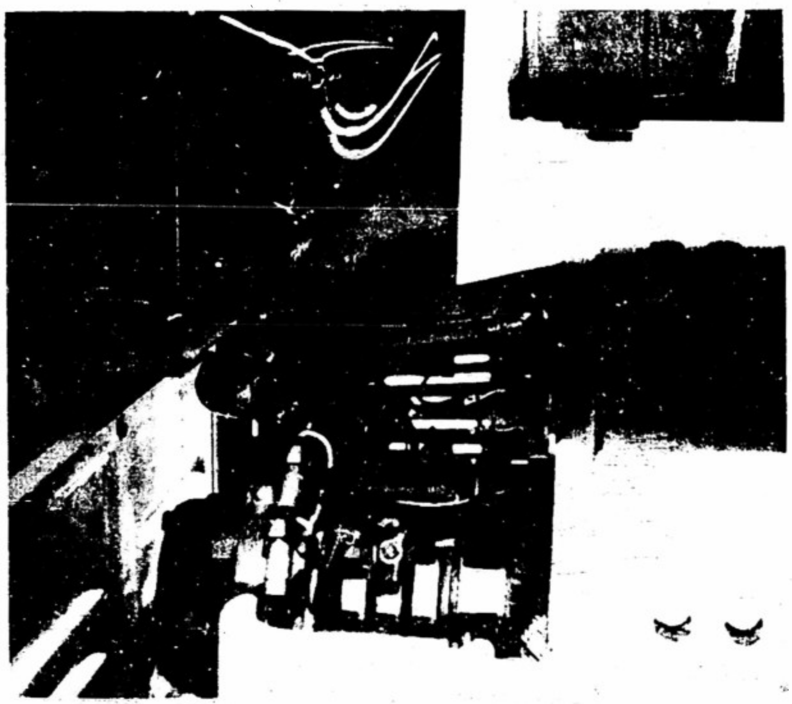

Figure 13. Correct placement of filter output leads.

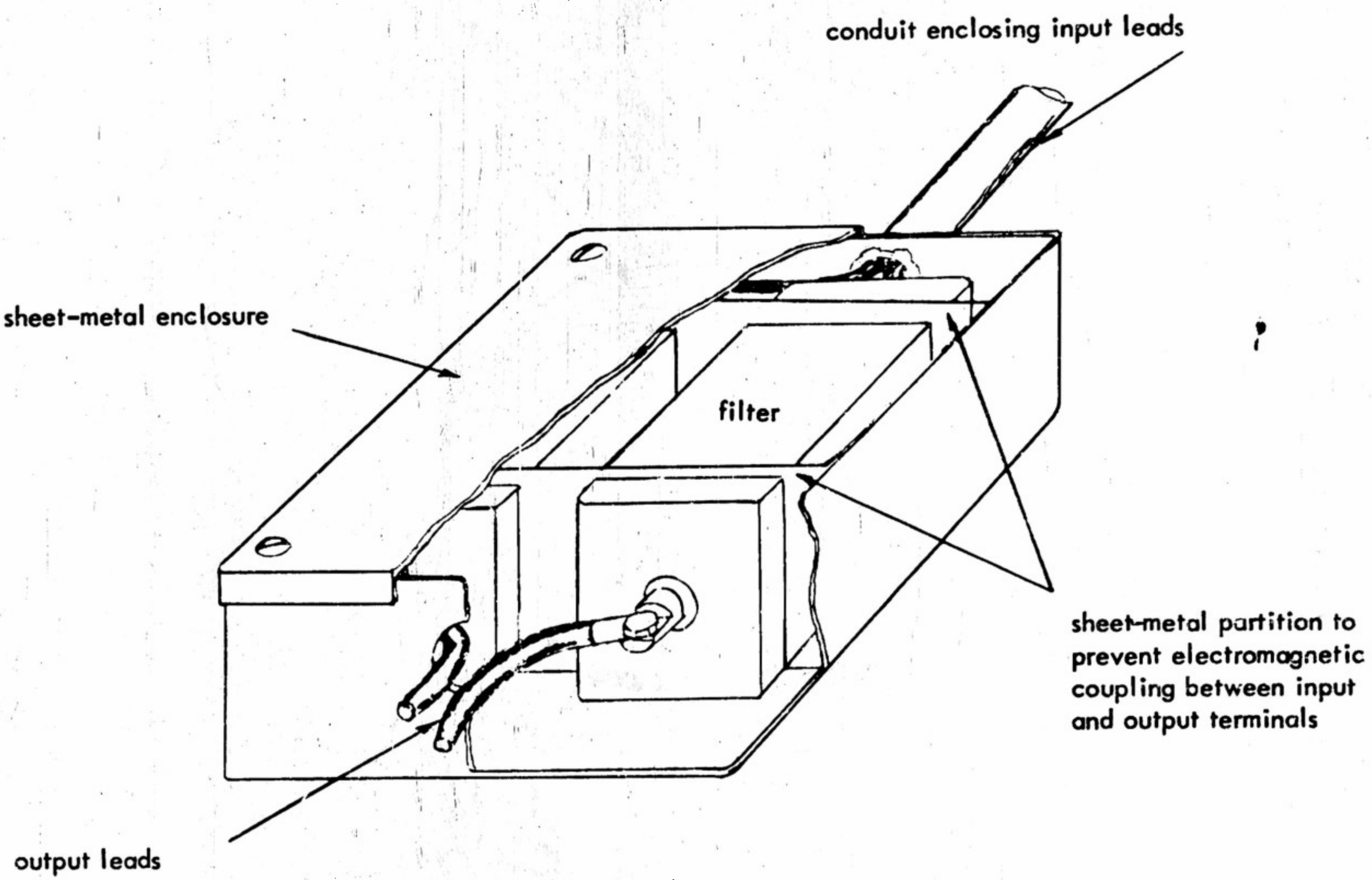


Figure 11. Filter enclosure.